Assembly of TPS Beam Position Monitor

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Abstract

Beam position monitors (BPM) of two types have been fabricated and are installed in the chamber of the storage ring of TPS; one is of elliptical type and the other is of racetrack type [1]. Both contain one beam duct and two flanges; each flange has two pieces of feedthrough that was designed and manufactured to have a small reflection coefficient [2]. A diamond-edged gasket is selected to seal to obtain an ultra-high vacuum. A SS304 set screw is used to compress the diamond-edge gasket between the aluminium chamber and the stainless-steel flange [3]. Alignment is achieved when one face of the flange contacts the chamber. The advantages of two (feedthroughs) in one (flange) design are ease of assembly and satisfactory control of dimensions. The flange is demountable, and two pieces of feedthrough are welded into the flange with a CO_2 laser beam. After that welding, the flanges are subjected to thermal shock to separate those of poor welding or brazing quality. The curve for the evacuation of one cell of TPS on which ten BPM flanges are mounted is also presented.

Layout of BPM for one cell of TPS

Seven BPM are installed in the chamber; the first and seventh of racetrack type and the others elliptical, illustrated in fig. 1 and 2. The associated materials are reported in table 1. Figure 3 describes the steps to mount a flange into the chamber; a detailed description follows: (1) place the flange inside the hole of the chamber; (2) stop slightly rotating the flange until two faces contact each other; (3) tighten every nut to 70 kg-cm gradually and equally.

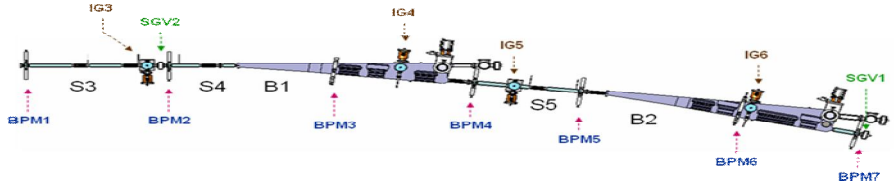

Fig 1: Sketch of TPS One cell; BPM are included.

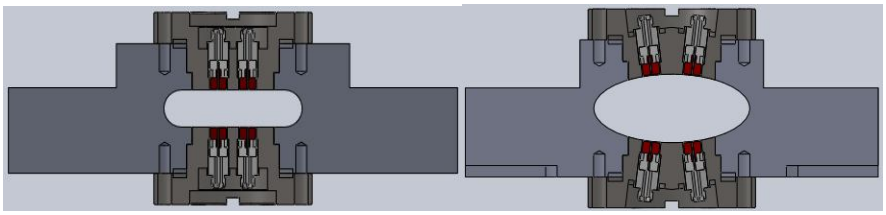

Fig 2: BPM structures of two types: racetrack (left) and elliptical (right)

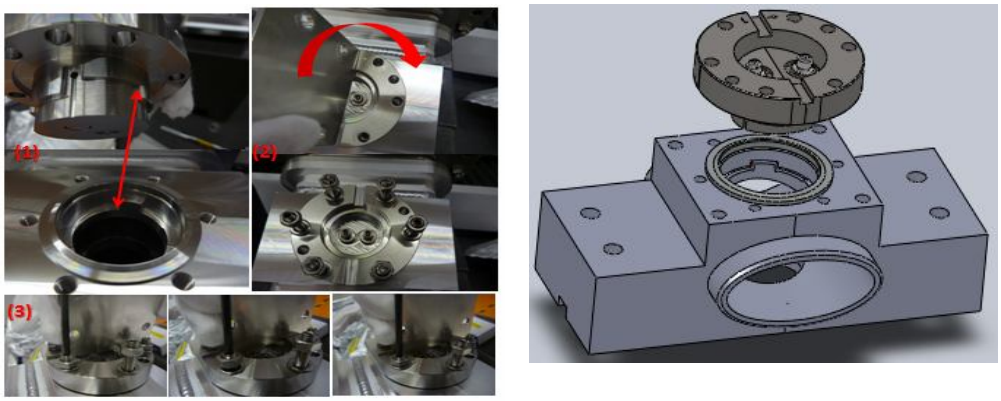

Fig 3: Steps to mount a flange into a BPM chamber (left); its related drawing (right)

Table 1: Materials of each part for TPS BPM

Name	Material
BPM flange	SS316L
BPM chamber	A6061T651
Diamond edge gasket	A1050H14

Manufacture of feedthrough

The drawing of a feedthrough and its related time-domain reflectometer (TDR) spectrum are shown in Fig. 4 and 5; the eccentricity is well controlled during the brazing. An adequate fixture should designed to maintain the eccentricity under 0.03 mm [4]. (the ceramic and Kovar housing) The impedance of each section of the feedthrough is designed to be about 50 Ω. The button is then welded with the beam of a YAG laser. The TDR spectrum of every feedthrough is measured and recorded before that YAG welding. The feedthrough with an unexpected TDR spectrum at the interface indicates that its structure differs from the original design.

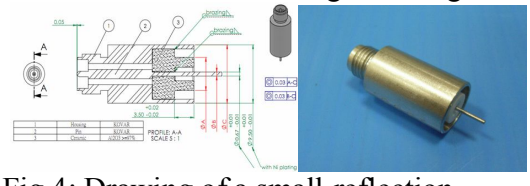

Fig 4: Drawing of a small-reflection feedthrough and the product.

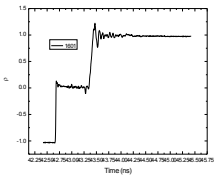

Fig 5:TDR spectrum of a small-reflection feedhtough

Fabrication of BPM

Two pieces of feedthrough made of Kovar are joined into the flange made of SS316L by welding with a CO_2 laser beam. To alleviate the rate of failure of CO_2 welding, the flange is designed to leave a protrusion of length 3 mm and thickness 0.75 mm illustrated in Fig 6. The heat is supposed to be concentrated on leaving an air gap adjacent to the feedthrough, but much heat concentration could induce a thermal strain inside the feedthrough. Many cases are detected after welding with a CO_2 laser beam such that a helium leak is found when the BPM flange suffers from thermal shock rather than the CO_2 laser beam welding, and the leak occurs in regions at sites of ceramic/metal brazing. Although decreasing the power of the CO_2 laser might improve that situation, the quality of welding becomes debased. After CO_2 laser beam welding, the TDR is again measured, and the capacitance of every button can be fitted; two flanges of similar capacitances are then combined to form a BPM set. Figure 7 shows the results of capacitance fitting of one TPS BPM flange.

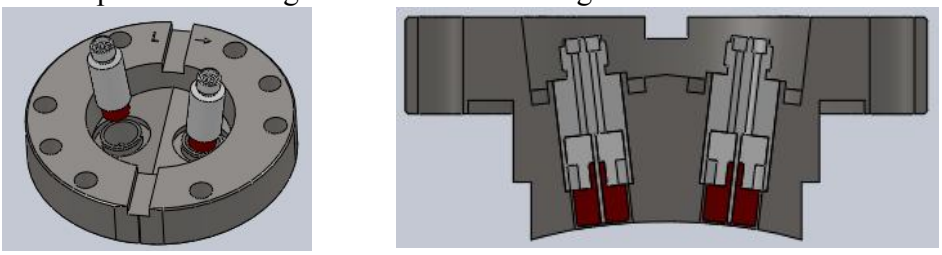

Fig 6: A protrusion is left for satisfactory quality of laser beam welding

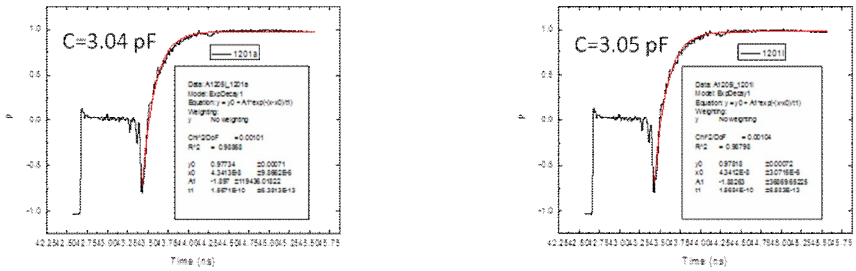

Fig 7: Capacitance fitting results of one BPM flange

Diamond gasket sealing

A1050H14 is selected for a diamond-edge gasket; it requires less torque than a copper gasket because of its smaller hardness [5]. SS304 is the suggested material for nuts and screws as its thermal expansion coefficient is smaller than that of aluminium. The ideal condition is that the total expansion length (T_s) that is the sum for the flange, gasket and chamber must be larger than the total expansion length resulting from the nut and screw (L_b). Table 2 shows the estimated length of thermal expansion for each part. The curve for evacuation of one cell before baking is presented in Fig 8. A leak is typically discovered when cooling from 150 ^oC to 25 ^oC; a way to avoid that leak is to re-torque the nuts about 100, 80 and 50 ^oC.

Table 2: Estimates of thermal expansion length for screws, flanges, chambers and nuts

SS/Al with SS bolt					
		thermal expansion	length /mm	dT	thermal expansion /μm
Al chamber	T_a	2.40 10^{-5}	13	150	0.046
Al gasket	T_g	2.40 10^{-5}	4.5	150	0.016
SS flange	T_{ss}	1.70 10^{-5}	13	150	0.033
total	$T_s = T_a + T_g + T_{ss}$				0.095
SS bolt	L_b	1.70 10^{-5}	30	150	0.077
	dL= dL_b- dT_s				-0.018

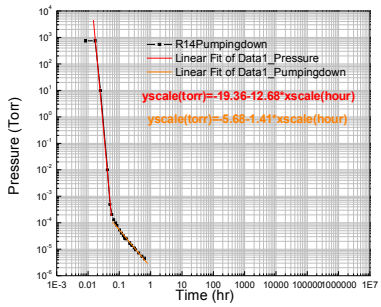

Fig 8: Evacuation curve for a BPM mounted on one cell

Summary

This paper describes a procedure to construct a TPS BPM. A feedthrough with a small reflection coefficient has been designed and manufactured. Two pieces of feedthrough are welded, with a beam from a CO_2 laser, into the stainless-steel flange. The usage of an A1050H14 diamond-edge gasket should sustain an ultra-high vacuum, but a leak typically emerges on cooling from 150 to 25 ^oC. Although re-torque of the nuts might eliminate the leak, we have not yet tested reliable and comfortable parameters for the use of a diamond-edged gasket. Upon baking, enough space for expansion of the gasket and a firm axial force to resist thermal stress are serious problems, especially as the two mating materials are dissimilar, requiring experiments to settle the issue. The BPM orientation is auto-aligned on rotating the flange against the chamber; a pin hole is unnecessary to position as long as the dimensions of each part are well controlled.

References

[1] G.Y. Hsiung, et al., "Vacuum Design of the TPS Relates to the Beam Effects", EPAC'08, THPP143, p.3699 (2008).

[2] I. T. Huang, et al., “Development of a Feedthrough with Small Reflection for the TPS BPM”, IPAC2011, San Sebastián, Spain, TUPS029, p. 1593 (2011).
[3] I. T. Huang, et al., “Design and manufacutre of TPS BPM diamond-edge gasket”, IPAC2012, Louisiana, USA, WEPPD023, p. 2549 (2012).
[4] Private communication with Bob Chen at Wave Power Technology Incorporated, Miaoli County 350, Taiwan (ROC)
[5] D. P. Yadav et al., “Development of UHV compatible machined diamond profile gaskets for INDUS-2”: J. Phys.: Conf. Ser. 114 (2008) 012019.